UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX

75 Hawthorne Street

San Francisco, CA 94105

July 8, 2016

Mr. Anthony R. Brown
Environmental Manager
Atlantic Richfield Company
4 Centerpointe Drive, LPR 4-435
La Palma, CA 90623-1066

Subject: **EPA Comments on Focused Feasibility Study Geotechnical Evaluation Task Sampling and Analysis Plan, Leviathan Mine Site, Alpine County, California, Leviathan Mine Site, Alpine County, California, Dated March 31, 2016**

Dear Mr. Brown:

The U.S. Environmental Protection Agency (EPA) has completed its review of the Focused Feasibility Study Geotechnical Evaluation Task Sampling and Analysis Plan, Leviathan Mine Site, Alpine County, California, Leviathan Mine Site, Alpine County, California, Dated March 31, 2016. This work was submitted to EPA pursuant to Administrative Order for Remedial Investigation and Feasibility Study, Leviathan Mine, Alpine County, California (CERCLA Docket No. 2008-18, June 23, 2008).

Background: EPA's 2008 Administrative Order included a description of the geotechnical investigations needed to complete the RI/FS at Leviathan Mine (Attachment A, Section I E). In response to EPA's order, ARC prepared the July 10, 2009 RI/FS Program Work Plan.

On February 26, 2010, EPA concurred that many of the stakeholder comments provided to ARC by EPA could be "…more appropriately addressed in the subsequent Focused Feasibility Study Work plans to be produced by Atlantic Richfield."

On May 13, 2010 EPA subsequently approved the July 10, 2009 PWP and a November 16, 2009 addendum with comments and direction. In that letter, EPA notes that *"ARC failed to include critical information to guide the RI activities at the site. EPA has produced the enclosed DQOs for the programmatic level summarizing available information, identifying decisions, and provide limits on the acceptable errors for those decisions"*

Excerpts from the programmatic DQOs are provided in Attachment B. On Page 6 of 53 of those DQO's, EPA mentions the need to investigate the stability of slopes and in situ rock forming high walls:

Summary. *The CSM identifies two primary sources of COPCs and associated release mechanisms.*

1. Mine Waste - COPCs might be released in airborne dust, storm water, and through water rock interactions. The geotechnical stability of mine wastes is uncertain.

2. In situ Rock - COPCs might be released through water-rock interactions. The stability of in situ rock forming the pit highwalls is uncertain.

Further, on Page 14 of 53 EPA also outlined the work necessary to be completed. Bullet 4 specifically states:

> *"Physical properties of the mine waste in each area, including properties affecting slope stability, and stability of response actions."*

On August 10, 2010, ARC submitted the On Property Focused Remedial Investigation (FRI) Work Plan. The On Property FRI work plan included goals for geotechnical characterization and evaluation, evaluation of storage pond expansion, and slope monitoring.

- In Section 11 of that workplan (pages 85 thru 90); ARC clearly outlined the Geotechnical work to be completed. (See Attachment C)
- In addition, ARC provided a schedule (Page 92 and Figure 22); indicating the Geotechnical Characterization and Evaluation, Investigation for Storage Pond Expansion, and Slope Monitoring would be completed by 4th Quarter2013. (See Attachment D)

On December 9, 2010 EPA approved ARC's On Property FRI work plan with comments and direction. EPA's Comment 1 mentioned the need for geotechnical investigations:

1) Investigation and data interpretation of the subsurface hydrogeology and geotechnical work must provide information necessary to examine potential interception of acid drainage at an elevation sufficiently above the streams and native soil areas to allow separation from uncontaminated areas, as well as collection, transport and treatment without significant pumping. Information from this FRI must be adequate to explore whether untreated releases and discharges can be completely controlled in both Leviathan Creek and Aspen Creek/Landslide areas, including the potential for storage in areas other than the current pond locations.

In that same letter dated December 9, 2010; EPA's Comment 6 clearly refers ARC to follow the RI Scope of Work attached to the June 2008 UAO:

6) The attached comments from the Lahontan Regional Water Quality Control Board dated November 30, 2010 provide a number of valuable observations and suggestions for consideration during implementation of this FRI and throughout the RI/FS. The Water Board's comments also discuss a potential imbalance of investigation effort throughout the study area. EPA's objectives are expressed clearly in the Scope of Work for the UAO. Atlantic Richfield is responsible for fulfilling the expectations of an acceptable investigation for all portions of the Study Area. EPA will continue to seek advice and input from a range of stakeholders during the planning and implementation stages of the RI/FS, in addition to the required review and comment periods prior the formal decision on long-term remedial action.

EPA's December 9 letter then **directed ARC to complete the work by 4th Quarter 201**3 in accordance with ARC's own schedule:

> With this approval notification, EPA directs Atlantic Richfield to implement the On-Property Focused Remedial Investigation (FRI) Work Plan at Leviathan Mine according to the schedule provided on Page 92 and Figure 22 of the FRI Work Plan.

EPA initiated two field visits that were completed on June 21, 2012 and July 10, 2014. John Sciacca with USGS and others participated in these two visits to assess the landslides in regards to data collection and assessment for the RIFS.

ARC has not submitted any follow-up documents or submittals for EPA review or consideration. EPA received the geotechnical investigation TSAP on March 31, 2016. EPA has reviewed the TSAP and conditionally approves the TSAP for field work to be completed during this 2016 field sampling season; with the following additional general and specific comments:

General Comments:

G1: Incomplete: The Geotechnical work plan is incomplete. It does not follow the tasks identified in the RI SOW attached to the June 2008 UAO. Nor does the work plan meet the objectives identified in the PWP and Programmatic DQOs. Atlantic Richfield's draft of the 2009 Programmatic Work Plan (PWP) acknowledged the need for geotechnical work in its own data quality objectives (DQO). Further, ARCs August 2010 On Property FRI Work Plan identified a geotechnical investigation (at Section 11). ARC's workplan does not include complete geotechnical investigation of landslides, high walls, mine waste, and pond areas in the current TSAP.

G2: SCOPE: A recent EPA and ARC telephone call regarding the scope of this workplan, clarified that ARC's intent is to apply this collected information to the evaluation of other storage pond expansion options. However, EPA still notes that part, Item E (Page 13) of the Statement of Work to the UAO clearly outlines the Geotechnical work to be completed. See Attachment A. Further, the work plan Atlantic Richfield provided on August 10, 2010, Section 11 pages 85 thru 89 (Attachment C) clearly outlined that the full scope of the Geotechnical work to be completed includes geotechnical characterization and mapping, evaluation of storage pond expansion, and slope monitoring. ARC should proceed with the work outlined in this TSAP. However the geotechnical work should be expanded to address Section I E of the RI SOW including expansion of storage at all of the ponds present, evaluation of slope stability on mine waste and high walls at the site, monitoring of slopes along the Leviathan Basin Landslide, and potential impacts to existing infrastructure such as existing roads, the Aspen Seep Bioreactor, and future infrastructure such as pipelines and new storage ponds.

G3: Purpose and Objectives: Atlantic Richfields March 31, 2016 TSAP is based on the two PWP objectives prepared by Atlantic Richfield in 2009, plus a third objective (GT-3, slope monitoring) identified in the August 2010 On Property FRI work plan. As indicated in the background section above, the PWP objectives provided by ARC were not accepted by EPA. Rather EPA prepared the program DQOs for Leviathan Mine in our December 9, 2010 letter (Attachment B).

The geotechnical evaluations described within the TSAP are narrowly constrained and focus on the use or modification of existing Ponds 2N and 2S, and visual inspection of the possible location for a potential future new pond. The proposed geotechnical investigation does not fully address the requirements in the RI SOW, nor the data gaps identified in the TSAP Appendix A, Engineering Evaluation of Existing Geotechnical Information. White Paper/Engineering Evaluation (Geotechnical WP/EE).

EPA requests that ARC provide a full and complete workplan for geotechnical investigations to assess the stability of pit high walls, steep slopes on mine waste, landslides, and existing infrastructure such as the Leviathan Mine Road and Aspen Seep Bioreactor, (the TSAP defers such investigations to future efforts), and to complete remedial design. The scope of the geotechnical investigation should be expanded to adequately support the feasibility study by addressing the data gaps identified in the Geotechnical WP/EE and to meet the requirements of the RI SOW.

G2: Consistency: The TSAP and Geotechnical WP/EE are inconsistent. The Geotechnical WP/EE identifies numerous geotechnical data gaps that are not addressed in the TSAP. For example, installation of inclinometers are identified as an activity for addressing data gaps at the Delta Slope in Section 5.2.2 of Appendix A, but are not included within the TSAP. The TSAP should include the activities for addressing the data gaps identified in the various sections of the Geotechnical WP/EE.

In addition the TSAP and Appendix A both use GT labels to identify investigation components. However, different components are given the same label in the two documents (for example, GT-1 in the TSAP refers to Geotechnical Characterization and Evaluation and GT-1 in Appendix A refers to Leviathan Creek Basin Landslide). Please ensure that the labels used in the TSAP and Appendix A WP/EE are consistent.

G3: Completeness: The TSAP does not address questions relevant to the narrow constraint outlined. For example, the investigation of the Potential Area for New Storage Pond is limited to geotechnical mapping. Geotechnical mapping alone would not fully address data gaps regarding the potential interactions of elevated pore pressures in the slopes adjacent to the future pond with slope stability. Nor does it assess whether movement of the Delta Slope or Leviathan Creek Basin Landslide could compromise the function of the pond. In addition, with no current knowledge of the movement of the Leviathan Creek Basin Landslide, it is difficult to determine how feasible the new storage pond would be. Please include additional investigations to provide site specific information regarding geotechnical soil properties, and slope movement rates (at the landslides) to address all data gaps prior to assessing the feasibility of a new storage pond.

Attached, please find a matrix relating potential effects of the Leviathan Creek Basin Landslide on possible components of potential future remedies as an example of the types of impacts this landslide could cause. Please ensure the geotechnical investigation is broadened to provide information to allow evaluation of the feasibility of implementing such potential remedies as expanding each of the existing storage ponds, building a new storage pond or ponds to capture acid drainage via gravity, and maintenance of infrastructure necessary to remediate the site.

Please prepare similar evaluations to support the rationale for the geotechnical investigations of other site features (including and not limited to assessment of the stability of slopes on mine waste piles, pit high walls, and Delta Slope) necessary to support the Leviathan Mine FS.

Specific Comments:

S1: Page 4: This information is not relevant to "Site Features." This paragraph should be moved to the end of the introduction before Section 1.1.

S2: Section 5.0, Scope of Work, Page 12: Tasks should be identical to those identified as necessary to address the data gaps identified in the Appendix A Geotechnical White Paper/Engineering Evaluation (WP/EE). In addition the data gaps should be related to the DQOs of Appendix B. As-is there appear to be multiple sources used to define the scope of the geotechnical investigation (DQOs of Appendix B, the WP/EE in Appendix A, PWP work plan, On Property FRI work plan, and broad unsupported statements regarding what is necessary to support the feasibility study within the TSAP text). Please develop the DQOs based on evaluation of existing information, and project requirements. Further, please develop the investigation tasks to address the data gaps identified during development of the DQOs. Please ensure the DQOs and WP/EE are integrated to develop a complete scope of work for the geotechnical investigations to address the RI SOW and fully support the feasibility study.

Appendix A, Geotechnical White Paper/Engineering Evaluation (WP/EE) Comments:

S3: Appendix A, Geotechnical WP/EE. Please make sure that references listed in Tables A-3A through A-3E and A-4 are consistent with those listed in the text.

S4: Appendix A, Geotechnical WP/EE. Please compare information from Tables A-3A through A-3E with the text and ensure it is consistent.

S5: Appendix A, Geotechnical WP/EE. Please insert the appropriate Geotechnical Evaluation Area in parentheses next to each header in Section 5.0. For example, change the header for Section 5.1 to: "Leviathan Creek Basin Landslide Area (GT 1)."

S6: Appendix A, Geotechnical WP/EE. Tables A-3A to A-3E. Please insert the appropriate Geotechnical Evaluation Area in the title of each table. For example, in Table A-3C, insert "Geotechnical Evaluation Area 3" beneath "POND EMBANKMENTS AND WASTE ROCK STOCKPILES."

S7: Section 3.0, last paragraph. Please reference Figure A-2 in the sentence preceding the GT list.

S8: Section 5.0. Please provide an introductory paragraph before Section 5.1 such as: "Area–specific data will be collected for five geotechnical evaluation areas, shown on Figure A-2. Tables A-3A, A-3B, A-3C, A-3D, and A3E summarize area-specific data (ASD) for geotechnical evaluation areas GT 1, GT 2, GT 3, GT 4, and GT 5, respectively, with details provided in Sections 5.1 through 5.5."

S9: Sections 5.1.1, 5.2.1, 5.3.1, and 5.4.1. Information Needed and Available. Last sentence "No information is required" is confusing, as the preceding sentence infers that information is required. Please remove this sentence.

S10: Section 5.1.4. Last sentence of first paragraph states that a 2D model will be used although significant 3D effects are anticipated. EPA requests that a 3D model be used. If not practical, please explain how a 2D model could be useful.

S12: Section 5.6, last paragraph. Table A4 does not list any proposed infrastructure. The limited geotechnical investigation includes visual inspection of the location for a future new storage pond. This new storage pond constitutes proposed new infrastructure. Please add the new storage pond and other potential future new infrastructure (for example pipelines) to the table.

S13: Section 6. Remote Sensing Survey is not included in bullets, but is listed on tables. Please include the remote sensing survey in a bullet.

Please implement the field tasks identified in this TSAP and provide a point by point Response to Comments (RTC) and a final TSAP with the recommended changes. The work outlined in this TSAP should be completed during the 2016 field season. EPA requests ARC provide a report to EPA within 90 days of the field work completion. As part of that submittal, please address all items in Attachments A, B and C. EPA notes that additional geotechnical investigations will likely be necessary to complete the FS.

If you have any questions, please feel free to contact me at (415) 947-4183 or Deschambault.lynda@epa.gov.

Sincerely,

Lynda Deschambault

Lynda Deschambault
Remedial Project Manager

Cc by electronic Email:
Douglas Carey, California Regional Water Quality Control Board, Lahontan Region
Lynelle Hartway, Washoe Tribe of Nevada and California
David Friedman, Nevada Department of Environmental Protection
Kenneth Maas, United States Forest Service
Tom Maurer, United States Fish and Wildlife Service
Toby McBride, United States Fish and Wildlife Service
Steve Hampton, California Department of Fish and Wildlife
Marc Lombardi, AMEC
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ATTACHMENT A: STATEMENT OF WORK, SECTION E OF RIFS JUNE 2008 (1 Page)

E. Geotechnical Engineering Evaluation

Conduct a geotechnical engineering assessment to evaluate the stability of existing impoundment berms and mine waste pile slopes, and high walls particularly during potential seismic events. The assessment will include the following tasks:

1. Review of groundwater level data collected from groundwater monitoring wells in the vicinity of the Leviathan Mine.

2. Completion of geophysical surveys across the Leviathan Mine and adjacent areas in an attempt to determine the stratigraphy and relative density of subsurface materials, and identify subsurface geologic features that may affect stability.

3. Visual inspection and assessment of the existing structures to evaluate whether additional investigations are necessary.

4. Completion of subsurface explorations to characterize the native materials beneath the mine waste piles and other areas of interest.

5. Assessment of mine shafts, adits, tunnels and galleries to determine their interaction and connection with other structures.

6. Geotechnical assessment of the existing evaporation pond berms for structural integrity as well as an assessment of the potential for increasing pond capacity through raising the berms and/or level of the outflow pipes. Consideration should be made of the seismicity of the surrounding area, height and competency of the impermeable liners and the effect of potential wave action.

7. Geotechnical assessment of mine waste slopes and high walls for stability and safety. Conduct an evaluation of the stability of high walls at the pit, stability of slopes on mine waste piles and associated areas. This evaluation should focus on identifying any areas where cut and/or fill or other engineering methods will be necessary to prevent the failure of slopes and associated hazards to human health and the environment. Evaluation of the optimal slopes for minimizing erosion and facilitating revegetation efforts shall also be made.

8. Landslide Area Evaluation. The landslide extending from the overburden waste pile to the vicinity of the confluence of Leviathan and Aspen Creeks is known to be active. Water quality of ponds and seeps indicates that acidic conditions are present within the landslide. The proximity of mine wastes at the head of the landslide begs the question as to whether continued movement of the slide could enhance the migration of mine wastes to the environment. A geotechnical assessment of the landslide area is necessary to determine the potential for mine wastes to be mobilized by continued landslide activity. In addition, investigations are necessary to determine if water flow through the landslide mobilizes mine waste constituents and/or contributes to continued instability of the landslide.

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ATTACHMENT B: EXCERPTS FROM THE MAY 2010 PROGRAMMATIC DQOs
(5 Pages)

Mine Waste

Estimates and measurements of the location, extent, physical characteristics, and chemical characteristics of mine wastes are necessary to support decision making in the RI/FS at Leviathan Mine. Decisions regarding mine waste are determined in part by Applicable or Relevant and Appropriate Requirements (ARAR), and in part through risk assessment. Potential ARARs such as portions of California Code of Regulations (CCR) Title 27 include prescriptive requirements for mine waste management. such as capping to minimize infiltration of water, and isolation from waterways. Classification of mine wastes in accordance with Title 27 depends on threats to water quality, acid-generating potential, whether the waste is readily containable and other factors. Risk assessment accounts for site-specific exposure and toxicity considerations.

These estimates and measurements will be supported in part by information from the Leviathan Mine database, and in part by collection of additional information. Sources of mine waste analytical data in the database include:

1. A 1977 University of Nevada at Reno Masters Thesis by Richard Butterfield: The Revegetation Potential of the Leviathan Mine Spoils. These data consist of agronomic soil analyses including pH of mine waste from Leviathan Mine.
2. Analytical results from field sampling performed in 1995 and 1996 by Vic Claassen and Michael Hogan of the University of California at Davis as part of revegetation efforts at the Leviathan Mine. These data consist of agronomic soil analyses of mine waste from Leviathan Mine. Measurements and analytes included pH, cation exchange capacity, organic matter, arsenic, boron, iron, manganese, and molybdenum.
3. A 1998 survey of field paste pH by SRK in mine waste at Leviathan Mine.

Information from these sources, and mineralogy and physical data for mine waste at Leviathan Mine reported by Hammermeister and Walmsley (1985) that are not included in the database are summarized below. These summaries are based on contents of the database and cursory review of Hammermeister and Walmsley (1985), and do not include review of the source documentation.

Butterfield (1977) reported information from the analysis of 13 surface samples of material described as 'spoil material' from Leviathan Mine. The locations of the spoil material samples were not included in the database, and the information is qualified as low documentation. In addition, this information was collected prior to the grading of mine wastes, construction of the ponds, and recontouring of the pit. The analytical methods used to determine metals contents are agronomic soil extraction methods, thus the resulting analytical values are not directly comparable to data generated using EPA methods and should not be used for supporting risk evaluations; however, the data may be relevant for use in evaluating the need for soil amendments for purposes of revegetation. The paste pH results (range from 2.9 s.u. to 7 s.u., mean 4.67 s.u.) are useful for evaluating the likelihood for the sampled material to create acid drainage when exposed to water.

Claasen and Hogan (1997) reported information resulting from the analysis of 30 mine waste samples collected from various areas at Leviathan Mine to evaluate soil chemistry for revegetation. The sample locations provided in the database are descriptive as to general area (for example 'surface soil from pit area'), but coordinates are not provided, and the information is qualified as rejected in the database due to lack of adequate location information. Analytical methods are not described in the database, thus comparability of these data to results from EPA analytical methods is questionable; however, the data may be useful in evaluating the need for soil amendments for purposes of revegetation. In addition, the data include cation exchange capacity and paste pH measurements. The paste pH results (range from 2.9 s.u. to 7.5 s.u., mean 4.48 s.u.) are useful for evaluating the likelihood for the sampled material to create acid drainage when exposed to water. The cation exchange capacity (CEC) results may be useful to evaluate potential ion exchange reactions as fluids migrate through the mine waste. The reported arsenic concentrations (12 samples, 40 milligrams/kilogram [mg/kg] to 720 mg/kg, mean of 262.5 mg/kg) show that mine waste at Leviathan Mine contains elevated total arsenic concentrations with respect to commonly used screening benchmarks.

SRK (1999) reported field paste pH and specific conductance (SC) measurements made at Leviathan Mine during July 1998. California State Plane Coordinate System locations of the samples are provided to the nearest 0.01 feet. The pH data are qualified as low documentation and the field conductance data are qualified as rejected in the database. The field paste pH measurements ranged from 1.85 s.u. to 8.65 s.u. with a mean of 4.59. The SRK paste pH measurements are consistent with the earlier paste pH measurements of Butterfield (1977), and UC Davis (1997) and show that exposure of some mine waste at Leviathan Mine to water results in the generation of acid drainage. The field SC measurements range from 10 to 5,600 with a mean of 272. The units for the field SC measurements are not documented by SRK (1999). Figure 4 shows SRK's reported locations and paste pH values at the site. Some material in each area containing mine waste, including the Overburden Area, is capable of generating acid drainage when exposed to water.

Hammermeister and Walmsley (1985) collected samples of mine waste from soil borings in the Overburden Area and used X-Ray diffraction to identify the minerals present. The summary table provided by Hammermeister and Walmsley did not differentiate mine waste from in situ rock. However the shallowest samples at boring locations within mine waste contained quartz, opal, tridymite, and smectite in major quantities; pyroxene, kaolinite, chlorite, alunite, and goethite in moderate quantities; and minor anatase, chlorite, natrojarosite, sanidine and pyrite. Quantitative analysis of clay minerals in mine waste showed that smectite is much more abundant than kaolinite or illite.

Existing information supports the conclusion that some mine waste may be a source for acid drainage when exposed to oxygen and water. Existing information also documents that some mine waste contains elevated total arsenic concentrations with respect to screening benchmarks. Available topographic information may also support evaluation of the extent and physical characteristics of mine waste in each area.

Additional information regarding the mine waste is needed to evaluate ARARs, assess threats to water quality, support risk assessments, identify remedial action objectives, and support the FS. Information about mine waste used in road construction is also important. This information includes:

1. Extent of mine waste in each area.
2. Metal contents (concentration, mass, mobility, and availability) of the mine waste in each area.
3. Chemical properties of the mine waste that affect acid generation (potential sources) and COPC transport in each area.
4. Physical properties of the mine waste in each area, including properties affecting slope stability, and stability of response actions.

Suitable sampling and analysis methods for gathering this information may include, but are not limited to, high resolution geophysical surveys of the disturbed areas and surrounding areas at Leviathan Mine, mine waste sampling and field analyses (for example paste pH, field XRF), mine waste sampling and laboratory analysis for chemical and physical properties, and visual observations. Mine waste sampling technologies such as hand tools, drilling equipment, and excavation equipment may be desirable. Analytical methods will be determined by the specific goals of a given investigation activity, and should provide defensible documented analytical data to support human health and ecological risk assessments, engineering decisions, and water quality assessment.

In situ Rock

Characterizing the quantity of acid drainage from in situ rock is necessary to evaluate the generation of acid drainage and exposure pathways and requires knowledge of the source(s) of water interacting with the rock, nature of water-rock interactions, physical characteristics (including fracture orientation and density, porosity, and permeability) of the in situ rock, extent to which in situ rock has been exposed to air and water through mining activity, and rock mineralogy. Therefore, estimates and measurements of the physical and chemical characteristics of mining impacted in situ rock and associated groundwater are necessary to support decision making in the RI/FS at Leviathan Mine.

Analytical data for in situ rock are not identified in the database. Some groundwater monitoring wells are completed within in situ rock; therefore, groundwater monitoring data exist. Historical mining records may also provide information about in situ rock characteristics.

Herbst and Sciacca (1982) mapped the geology of Leviathan Mine before grading was completed to construct the ponds and the concrete lining of Leviathan Creek. Their observations provide for the identification of geologic units and structures at Leviathan Mine.

Hammermeister and Walmsley (1985) collected samples of in situ rock from borings in the Overburden Area, landslide, and along Leviathan Creek; and used X-Ray diffraction to identify the minerals present. The summary table provided by Hammermeister and Walmsley did not differentiate mine waste from in situ rock. However the deeper samples at these boring locations contained plagioclase, smectite, orthoclase, cristobalite, and calcite in major quantities; quartz, pyroxene, and smectite in moderate quantities; and minor pyroxene, muscovite, kaolinite, pyrite, pentlandite, rhodochrosite, corellite, and quartz. Quantitative analysis of clay minerals present in in situ rock showed that smectite is much more abundant than kolinite or illite.

Existing information documents that at least one tunnel remains open within in situ rock. Most of the other underground mine workings may have been eliminated during development of the open pit. The open pit appears to have unstable high walls. Acid drainage emanating from the Adit indicates that in situ rock exposed to oxygen and water by mining activity creates acid drainage.

Additional information regarding the in situ rock is needed to identify remedial action objectives, and support the FS. This information may includes:

1. Location and extent of remaining underground mine workings.
2. Source of water contributing to acid generation from in situ rock.
3. Metal contents (concentration and mass) and mineralogy of the in situ rock disturbed by mining as necessary to assess acid generation and exposure pathways.
4. Chemical properties of selected in situ rock that affect acid generation and COPC transport.

5. Physical properties of the selected in situ rock disturbed by mining, including physical properties that support evaluation of slope stability in vicinity of the pit high wall and remaining underground mine workings.

Suitable sampling and analysis methods for gathering this information may include high resolution geophysical surveys of the in situ rock disturbed by mining and surrounding areas at Leviathan Mine, sampling and field analyses (for example water quality parameter measurement and field XRF), sampling the in situ rock and laboratory analyses for chemical and physical properties, installing monitoring wells, and sampling groundwater, hydraulic testing, and visual observations. In situ rock sampling technologies such as hand tools, drilling equipment, and excavation equipment may be desirable. Various drilling technologies and well materials are available for consideration. Analytical methods will be determined by the specific goals of a given investigation activity, and should provide defensible documented analytical data to support human health and ecological risk assessments, engineering decisions, and water quality assessment.

ATTACHMENT C: AUGUST 2010 ON PROPERTY FRI WORK PLAN SECTION 11 (6 pages)

11.0 GEOTECHNICAL INVESTIGATION

The objectives of the geotechnical investigations are to evaluate whether the current geotechnical stability of mine waste and other on-property features (including pit walls, channels, and impoundment structures) pose an acceptable risk during remedy implementation or to the long-term effectiveness of potential remedies and whether the stability needs to be evaluated through further study.

Three tasks are associated with geotechnical investigations:

- Task GT-1 – Geotechnical Characterization and Mapping,
- Task GT-2 – Evaluation of Storage Pond Expansion, and
- Task GT-3 – Slope Monitoring.

Task GT-1 consists of identifying and characterizing geotechnically significant features. Task GT-2 consists of evaluating the need to expand the storage ponds and geotechnical feasibility of expanding the ponds. Task GT-3 consists of using existing and new slope monitoring monuments to evaluate movement of the pit walls and the LCBL. Additional geotechnical tasks will be developed as potential remedial options become more clear during the RI/FS.

11.1 GEOTECHNICAL CHARACTERIZATION AND EVALUATION (TASK GT-1)

The purpose of the geotechnical characterization and evaluation is to identify features (e.g., the pit walls, landslides, and impoundments) that may be geotechnically significant, characterize the geotechnical conditions associated with these features, and complete preliminary geotechnical evaluations that may be necessary to support the feasibility study of remedial alternatives. Geotechnical characterization and evaluation will consist of data collection and mapping, geotechnical characterization, and preliminary data evaluation. A baseline report will be prepared. Implementation of this task will rely on visual observations and mapping, existing site subsurface data, existing site construction or as-built information, existing geologic mapping, and relevant published information.

The scope of work described in this section is intended to generate the data needed to develop a representative interpretation of geotechnical conditions at a sufficient level of detail to provide a rational basis for future planning and decisions. Because geotechnical investigations and design are frequently iterative, future subsurface investigation and laboratory testing to support remedial design should be expected.

11.1.1 Data Collection and Mapping

Site features that may be geotechnically significant will be identified, mapped, and visually inspected. In addition, existing construction drawings and/or as-built documentation will be collected and reviewed. This information will be compiled with geologic mapping, lithologic information, geophysical survey results, and other relevant existing information to prepare a site map (or maps) that will be used to support geotechnical evaluations going forward. Specific work tasks consist of:

- Visual inspection and mapping to identify and plot the limits of features such as the pit walls, landslide areas, and man-made structures. During the course of this work, particular attention will given to the identification and mapping of features such as tension cracks, areas of sloughing, head scarp areas, toe displacement, springs, and settlement.
- Visual inspection of the Delta Slope for instability (tension cracks, settlement, and slope movement) and groundwater seeps.
- Collection and review of construction drawings and as-built documentation that may be available for the various man-made structures present at the site. This information will be compiled and used to support preparation of representative cross sections through the features and structures of interest (Section 11.1.2).
- Collection and interpretation of aerial photographs and existing LIDAR data to better characterize the limits of landslides and to identify geologic or geomorphic features that may be important to the geotechnical characterization of the site.

11.1.2 Geotechnical Characterization

Based on the results of the data collection and mapping described above, geotechnical conditions will be characterized at each of the features judged to be potentially important. The final work product of this subtask will be a series of geologic cross sections through the features or structures of interest at a sufficient level of detail to perform preliminary geotechnical evaluations to support the identification and subsequent feasibility evaluations of possible remedies. To the extent feasible and appropriate, the cross sections will show applicable data (e.g., boring locations, tension cracks, scarps, etc.) and man-made structures and will identify areas of uncertainty associated with the sections.

11.1.3 Preliminary Evaluations

The results of data collection and mapping and geotechnical characterization will be used to identify geotechnical issues of potential concern associated with the different site features and to identify and complete preliminary evaluations that may be warranted to support remedial investigations and feasibility studies. The evaluations may include:

- **Static Stability**. Static stability analyses will be completed using generally accepted limit equilibrium methods. For cases where geologic structure may influence or control stability, kinematic assessments will be completed to identify bedrock discontinuity surfaces (or intersections of surfaces) that may be critical. For the purpose of this work plan, it is assumed that material-specific geotechnical properties such as unit weight and shear strength will not be available. In these cases, material properties will be assumed based on previous experience with similar materials, published information, and judgment. The basis for all assumptions will be justified and documented in the geotechnical baseline report (Section 11.1.4). Groundwater conditions for analysis will be based on existing site data or will be estimated to provide a representative range for the site.

- **Seismic Stability**. Seismic stability will initially be evaluated using pseudostatic methods. Depending on the pseudostatic results and as applicable, preliminary displacement analyses will be completed using accepted decoupled procedures (e.g., Makdisi and Seed, 1977; Bray and Rathje, 1998). As part of this work, the seismic characterization of the site will be reviewed and updated as necessary using current seismic hazard information (e.g., Petersen et al., 2008; Field et al., 2008) and Next Generation Attenuation (NGA) relationships (e.g., Abrahamson and Silva, 2008; Campbell and Bozorgnia, 2008).

- **Liquefaction**. Based on currently understood conditions, the potential for liquefaction is judged to be low. This interpretation will be verified based on the results of data collection and mapping, geotechnical characterization, and the updated seismic hazard assessment for the site. If liquefaction is judged to be a potential concern, additional evaluations will be performed to evaluate its potential if sufficient data are available for this type of assessment. Recommendations for additional data collection will be developed as necessary.

- **Settlement**. Areas potentially susceptible to settlement will be identified based on the results of data collection and mapping and geotechnical characterization. The potential effects of settlement with respect to remediation will be qualitatively evaluated and recommendations for additional data collection will be developed as necessary.

11.1.4 Baseline Report and Recommendations

A geotechnical baseline report will be prepared to document the results of the previous tasks, to support the RI/FS process, and to provide a guide for additional investigations. The report will address the following generalized outcomes for the different features and structures of interest:

- Based on the evaluation, geotechnical conditions at one or more of the investigated site features or structures are such that additional investigation is warranted prior to identifying and evaluating a remedial measure in the area of interest.

- Based on the evaluation, geotechnical conditions at one or more of the investigated site features or structures are such that additional investigation and evaluation is not necessary now but will probably be warranted to support final design of the selected remedy.

- Based on the evaluation, geotechnical conditions at one of more of the investigated site features or structures are such that the feature by itself poses an unacceptable risk.

- Based on the evaluation, geotechnical conditions at one or more of the investigated site features or structures are sufficiently well understood that additional investigation is probably not warranted now or in the future.

Specific recommendations for additional work will be provided as warranted. Such work could include additional subsurface borings, geophysical investigation, laboratory testing, and/or the installation of a variety of monitoring instruments such as slope inclinometers or settlement monuments. The report will include relevant supporting information in appendixes to the report and will document the assumptions and uncertainties associated with the preliminary analyses.

11.2 EVALUATION FOR STORAGE POND EXPANSION (TASK GT-2)

Evaluation for storage pond expansion consists of two components: 1) evaluating the need for expanding the storage capacity of the ponds and 2) evaluating the geotechnical feasibility of expanding the storage capacity of the ponds.

11.2.1 Storage Capacity Evaluation

The existing capacity of storage ponds in the LCSA will be evaluated to determine the need for expansion to increase winter storage capacity. More specifically, this evaluation will be conducted to determine the probability of Ponds 1, 2N, 2S, 3, and 4 containing winter (approximately November through April) flows from the Aspen Seep, Delta Seep, CUD, PUD, and the adit. The analysis will include an investigation of various cumulative winter precipitation data, probable total seep flow volumes, and evaporation volumes. The objective is to determine the probability of exceeding the existing pond capacity based on analysis of precipitation and seep flows.

The analysis will be performed using:

- cumulative winter precipitation volumes,

- cumulative winter evaporation volumes,

- cumulative winter seep discharge volumes, and

- pond capacity volumes.

The existing data will be evaluated and appropriate data sets will be developed as needed. The return interval of probable climate and seep flow conditions that will cause an exeedance of combined pond capacity will be assessed.

11.2.2 Geotechnical Assessment for Pond Expansion

Expansion of one or more of the existing water storage ponds (Ponds 1, 2N, 2S, 3, and 4; Figure 2) is reasonably expected to be identified as a potentially applicable remedial technology that will require feasibility evaluation. For the purpose of this work plan, it is assumed that storage pond expansion could include deepening the existing ponds, raising the heights of the perimeter embankments, increasing the lateral limits of the ponds, consolidating and relocating the surface water storage structures, or a combination of these alternatives.

Because the feasibility of expanding the capacity of the ponds will be largely dependent on the geotechnical characteristics of the existing pond containment berms, containment systems, and subsurface/foundation conditions, additional early geotechnical characterization and assessment of these structures is warranted to support this evaluation. The most significant of these issues is likely to be associated with the thickness and characteristics of overburden, waste rock, and native materials underlying the ponds and potential expansion areas.

The final scope of work for this task will depend largely on the results of geotechnical characterization (Section 11.1.2) but likely will include:

- Advancing borings to collect samples of existing containment structures (perimeter berms, soil fill, and soil base liner material), underlying waste rock, and underlying native geologic materials. For the purpose of this work plan, it is assumed that the borings will be advanced using sonic drilling techniques and that relatively undisturbed samples of the material will be obtained. In the event liquefaction is judged a potential concern, the relative density of the underlying materials will be evaluated by completing standard penetration tests (SPTs) and/or cone penetration tests (CPTs). SPT blow counts and CPT data provide much of the fundamental information needed to evaluate liquefaction triggering (i.e., whether liquefaction will or will not occur during the design earthquake for a site).

- As necessary or appropriate, excavating test pits at and near the perimeter of the storage ponds to observe existing embankment fill conditions and to obtain representative samples for testing.

- Laboratory testing of selected samples recovered from the borings. Tests that may be performed include classification and index properties such as moisture content, dry density, plasticity (Atterberg limits), and grain size distribution; peak and residual shear strength; consolidation; and/or expansion and collapse tests. All tests will be performed in accordance with applicable ASTM standards.

The results of the field and laboratory test program will then be used as a basis for geotechnical analyses needed to identify potentially applicable alternatives and to support a feasibility level evaluation of storage pond expansion.

11.3 Slope Monitoring (Task GT-3)

Slope monitoring will consist of evaluating movement of mine waste in the ACSA and evaluating slope movement in the PSA. During the visual inspection performed in Task GT-1, the existing slope monitoring monuments installed in the ACSA (SRK, 1999) will be located and their condition will be evaluated. If the monuments are still intact they will be used; if needed, new surface monitoring monuments will be installed. In the PSA, slope monitoring monuments will be installed where feasible along the top of the pit wall or at other locations where movement appears to be occurring. Up to 10 monuments will be installed. Baseline survey measurements will be collected and the devices will be monitored monthly for the duration of the field season the first year. Based on the first year of data, an appropriate long-term monitoring schedule will be designed. The surface elevations monuments will be installed in accordance with SOP 33.0 (Installation of Slope Monitoring Monuments).

ATTACHMENT D: AUGUST 2010 ON PROPERTY FRI SCHEDULE Figure 22 (1 Page)